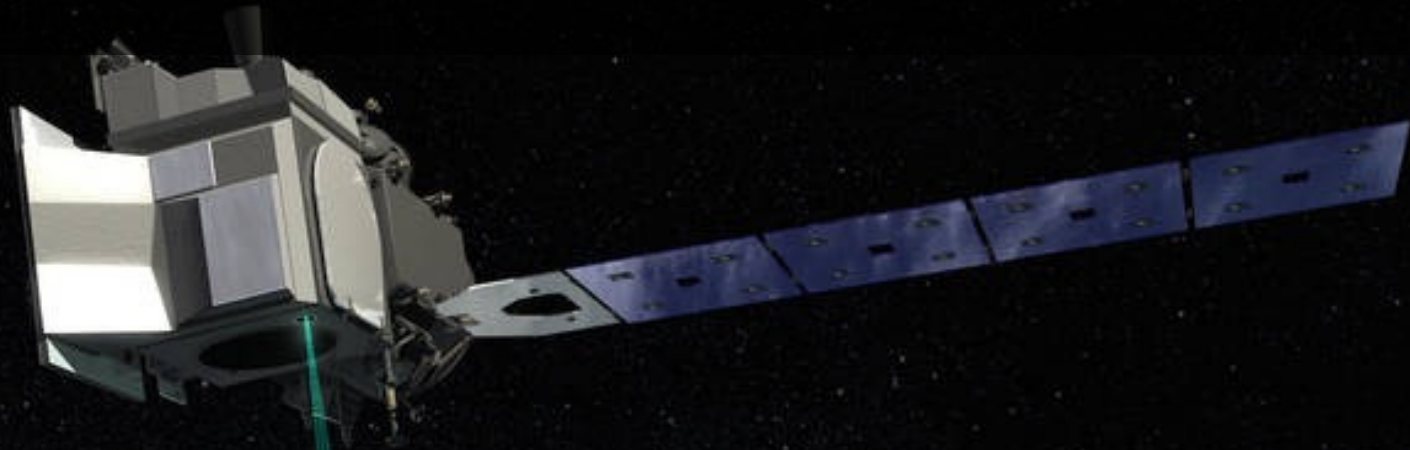


The ICESat-2 Mission



Tom Neumann, Goddard Space Flight Center

Amy Neuenschwander, University of Texas at Austin

with contributions from

Eric Guenther, University of Texas at Austin

Steven Hancock, University of Edinburgh

Laura Duncanson, University of Maryland

Paul Montesano, NASA Goddard Space Flight Center

Mike Wulder, Canadian Forest Service

Joanne White, Canadian Forest Service

Jordon Borak, NASA Goddard Space Flight Center

Milutin Milenkovic, Wageningen University

Current Status

1133 days on orbit since launch (half during quarantine)

ATLAS: transmitting laser light since 1 October 2018

990 billion laser pulses (compared with 2 billion from ICESat)

6 beams, arranged in pairs

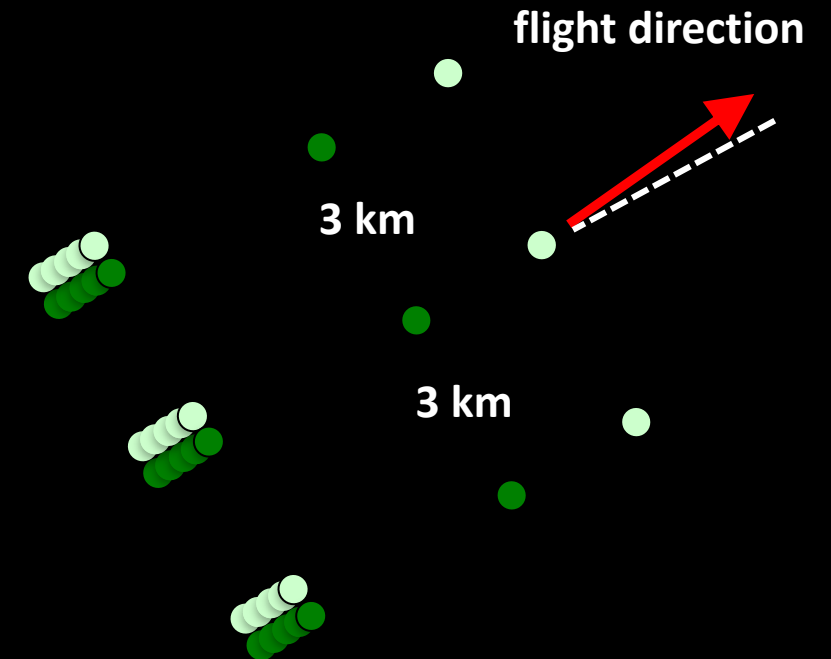
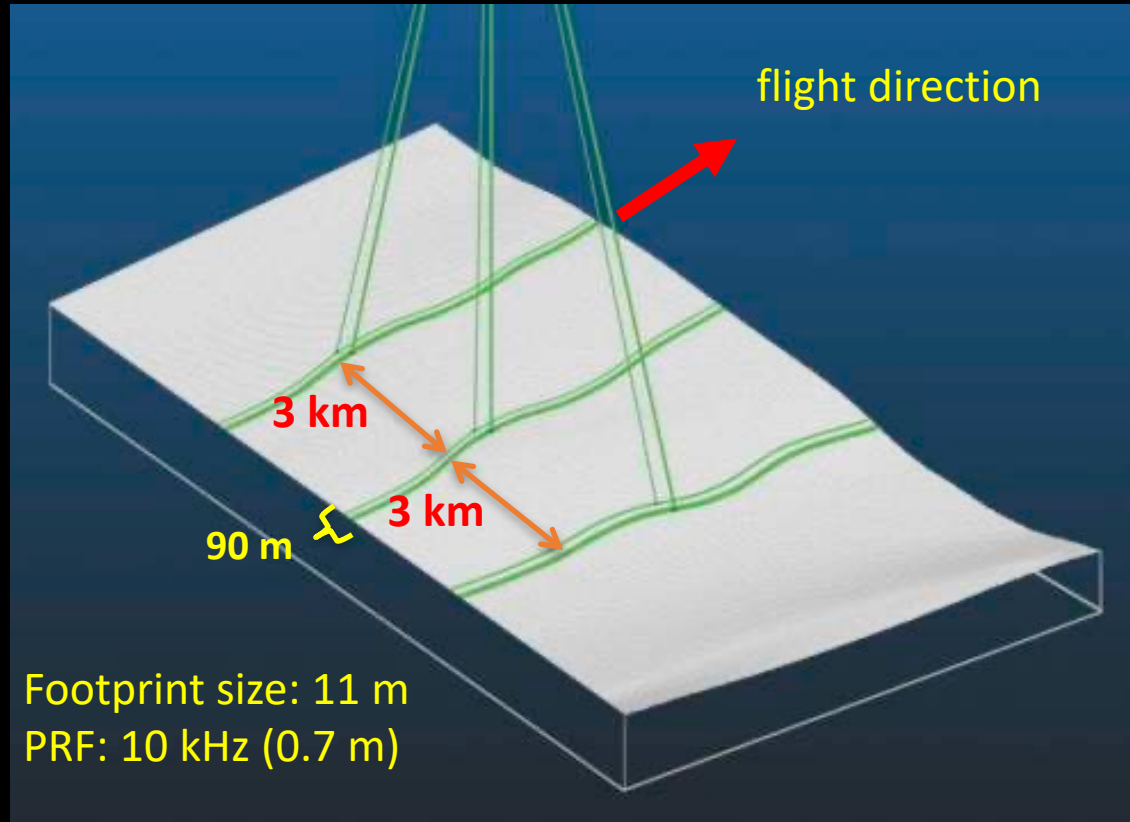
11 m footprint diameter

0.7 m along-track spacing

Performance metrics remain nominal, and within requirements

92 degree orbit inclination angle means ICESat-2 collects data globally

Single laser pulse at 532nm, split into 6 beams. Single-photon sensitive detection.



3 km spacing between pairs provides spatial coverage

90 m pair spacing for *slope determination*

high-energy beams for better performance over low-reflectivity targets.

ICESat-2 data product bottom-line:

ICESat-2 height accuracy is currently better than 10 cm (but it really depends on your particular terrain)

ICESat-2 horizontal location accuracy is currently better than 5 m

ICESat-2 effective footprint diameter is ~11 m

Pointing control is ± 45 m for targets of opportunity

Pointing control for repeat ground-track tracking is ± 10 m

National Snow and Ice Data Center (NSIDC DAAC): Data Product Inventory

ATL03: Geolocated Photons

ATL06: Land Ice Elevation and along-track height timeseries

ATL07: Sea Ice Elevation and along-track/gridded freeboard

ATL08: Land Elevation and Vegetation

ATL09: Atmospheric Backscatter and weekly/monthly profiles

ATL12: Ocean Surface Height

ATL13: Inland Water Elevation

3465 registered users

13.5 million files downloaded

Final products available for Oct 18, 2018 – July 15, 2021

NASA Distributed Active Archive Center (DAAC) at NSIDC

ICESat-2 Data

Ice, Cloud, and Land Elevation Satellite-2 Data

Overview

ICESat-2 Data Sets

Product Descriptions

Level-1

Level-2

Level-3A

Level-3B

Tools

Knowledge Base

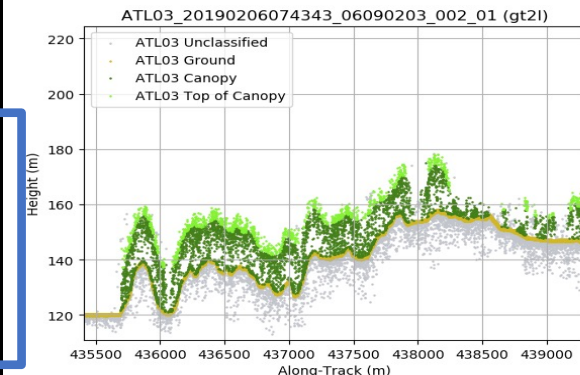
ICESat/GLAS Data

IceBridge Data

ICESat-2 Data Sets at NSIDC

The following table lists the ICESat-2 data sets that are currently available at the NASA NSIDC DAAC.

ID	Title	Spatial Coverage	Temporal Coverage	Spatial Resolution	Temporal Resolution	Parameter(s)
ATL02	ATLAS/ICESat-2 L1B Converted Telemetry Data, Version 1	GLOBAL	2018/10/13 to present	Not applicable	Not applicable	Engineering Telemetry Ancillary Data
ATL03	ATLAS/ICESat-2 L2A Global Geolocated Photon Data, Version 1	GLOBAL	2018/10/13 to present	70 cm	91 day	TERRAIN ELEVATION
ATL04	ATLAS/ICESat-2 L2A Normalized Relative Backscatter	GLOBAL	2018/10/13 to present	280 m	91 day	Lidar Backscatter



*ATL03/ATL08
data over
vegetated
topography in
Finland*

National Snow and Ice Data Center (NSIDC DAAC):

Available tools (mostly in python) to facilitate access and use of data products.

Community continues to develop data tools:

Hackweek(s)

OpenAltimetry

PhoREAL


icepyx

Photon Labeller

NASA Distributed Active Archive Center (DAAC) at NSIDC

ICESat-2 Data

Ice, Cloud, and Land Elevation Satellite-2 Data



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ICESat-2 Tools and Services

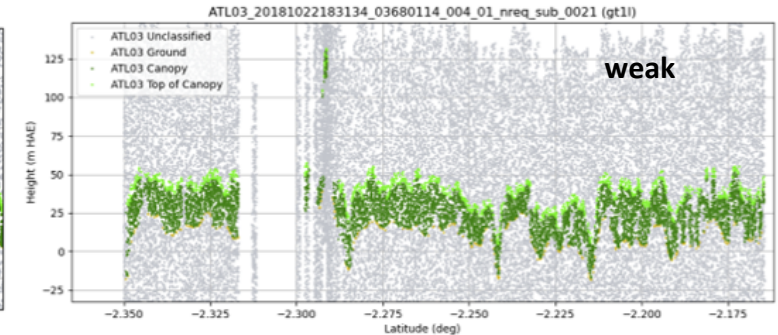
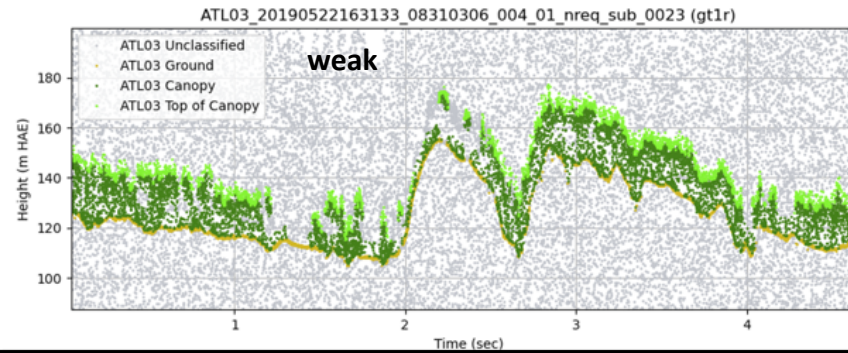
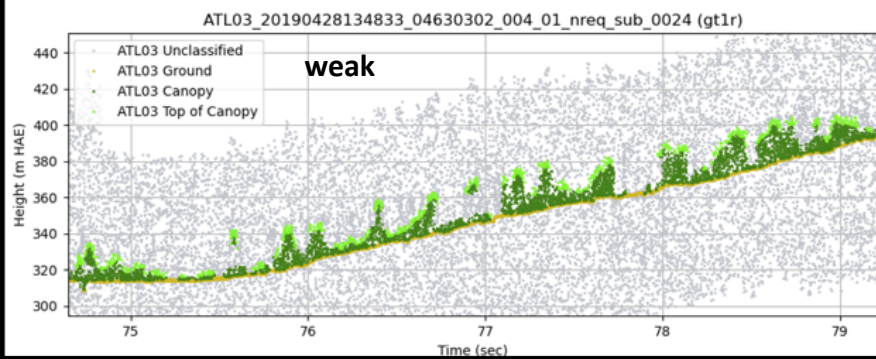
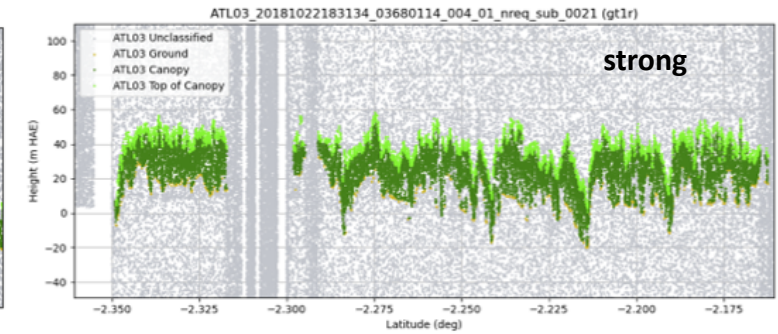
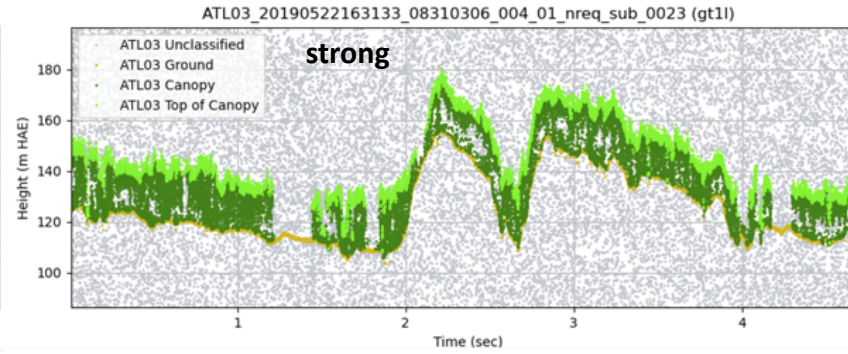
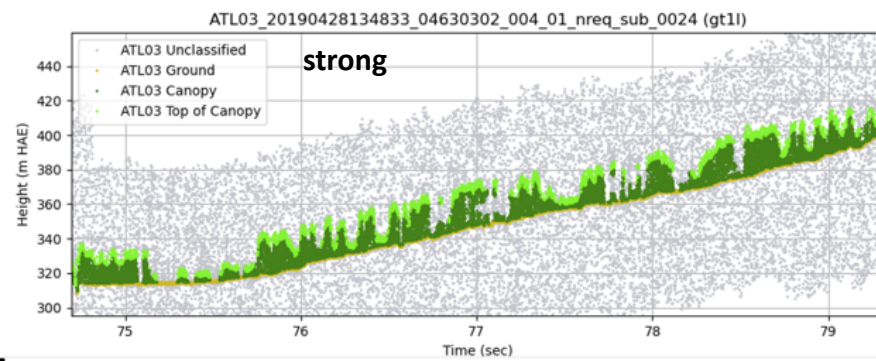
The following table lists the tools and services available for ICESat-2 data.

Name	Description	Access Type	Service Outputs	Source
OpenAltimetry	Discover, access, and visualize ICESat and ICESat-2 data. Key functions include on-the-fly plotting of segment elevations and photon clouds based on date and region of interest, ground track filtering and visualization, and data access in CSV or subsetted HDF5 format.	Web application	<ul style="list-style-type: none"> Downloadable elevation and photon plots Spatially subsetted HDF5 data CSV output of key parameters 	A NASA funded collaborative project between the Scripps Institution of Oceanography, San Diego Supercomputer Center, NSIDC DAAC, and UNAVCO.
NASA Earthdata Search	Search, visualize, and access data across thousands of Earth science data sets, including ICESat, IceBridge, and ICESat-2. Customization services are available for most ICESat-2 data sets, including subsetting and reformatting.	Web application	<ul style="list-style-type: none"> Data access via shell script and zip links Visit the page What subsetting and reformatting services are available for ICESat-2 data? for details on subsetting and reformatting services available for each ICESat-2 data set. 	NASA EOSDIS , supported by NSIDC DAAC .
Data Access and Service API	The NSIDC DAAC's Application Programming Interface, or API, provides spatial and temporal filtering as well as customization options as a single access command, without the need to script against our data directory structure.	API	Visit the page What subsetting and reformatting services are available for ICESat-2 data? for details on subsetting and reformatting services available for each ICESat-2 data set.	NSIDC DAAC
ICESat-2 Hackweek Jupyter Notebook Tutorials	A Github repository of Jupyter Notebook tutorials presented during the ICESat-2	Downloadable tool	Python-based guidance on access, reading, plotting, and	ICESat-2 Hackweek , hosted by the University of Washington with

Photon Sampling



ATL08 (Land and Vegetation Data Product) Strong vs Weak Beams



Alberta, Canada

Germany

Tapajos, Brazil

ATL08 photon labels mapped to ATL03 geolocated photon product

Global Canopy Heights

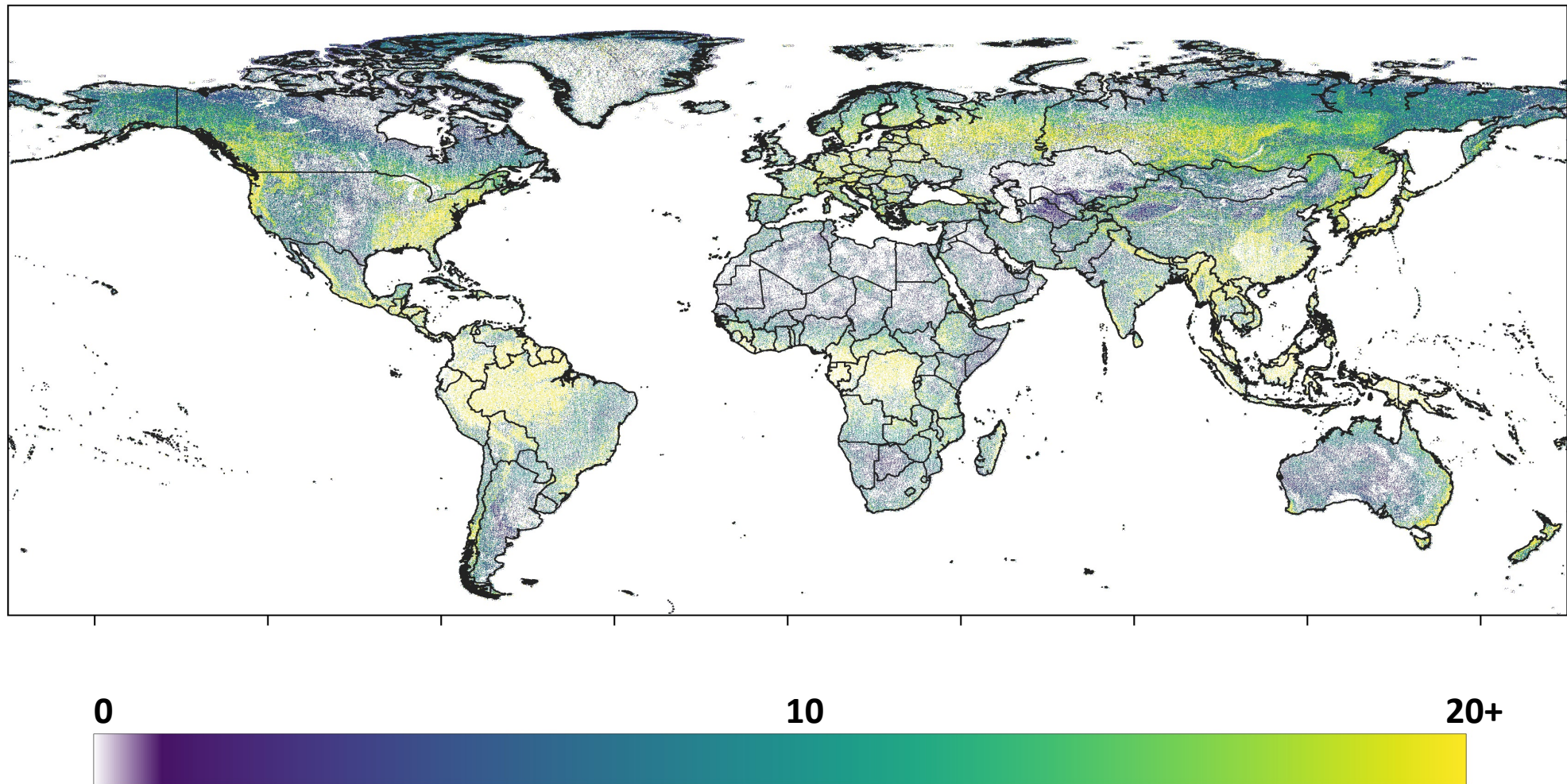
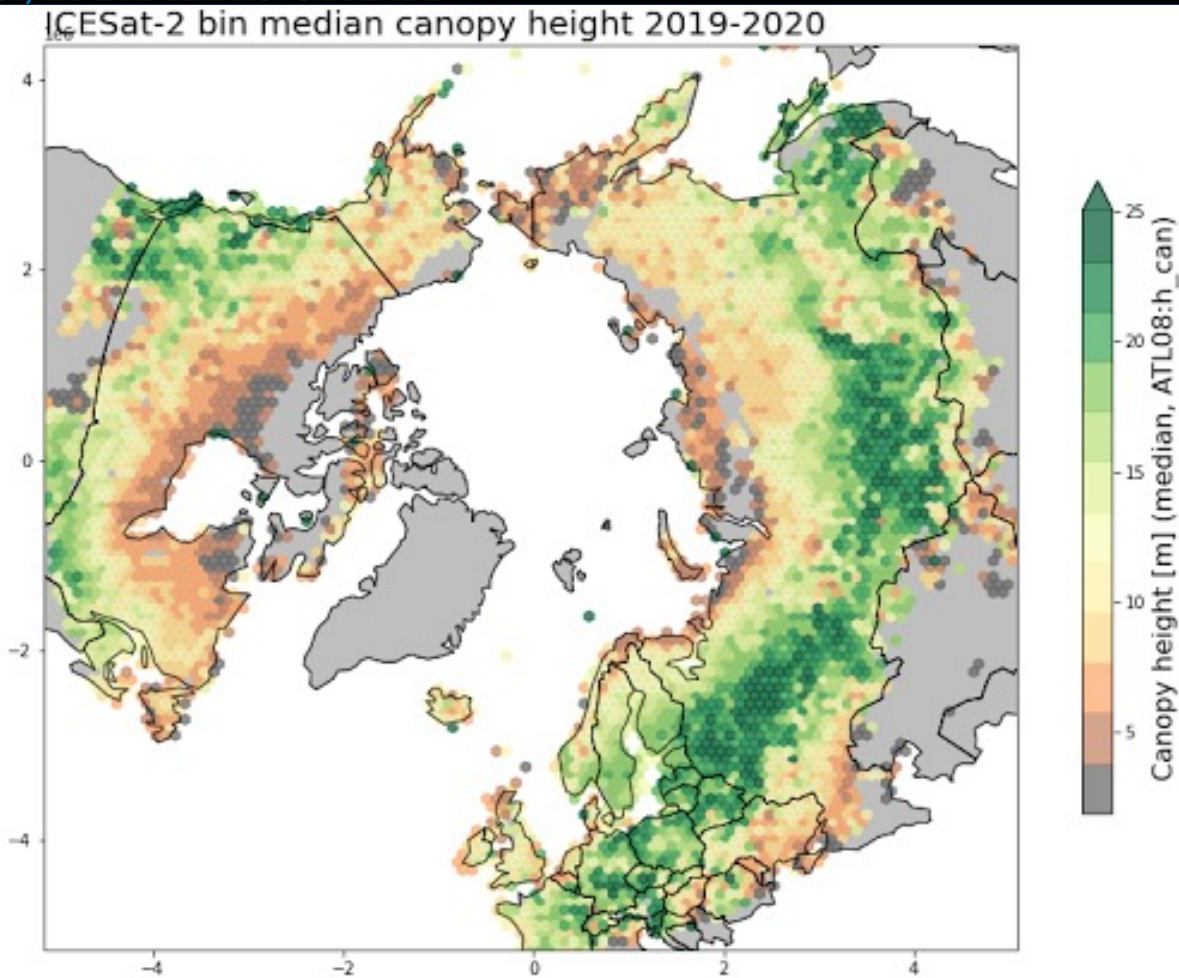


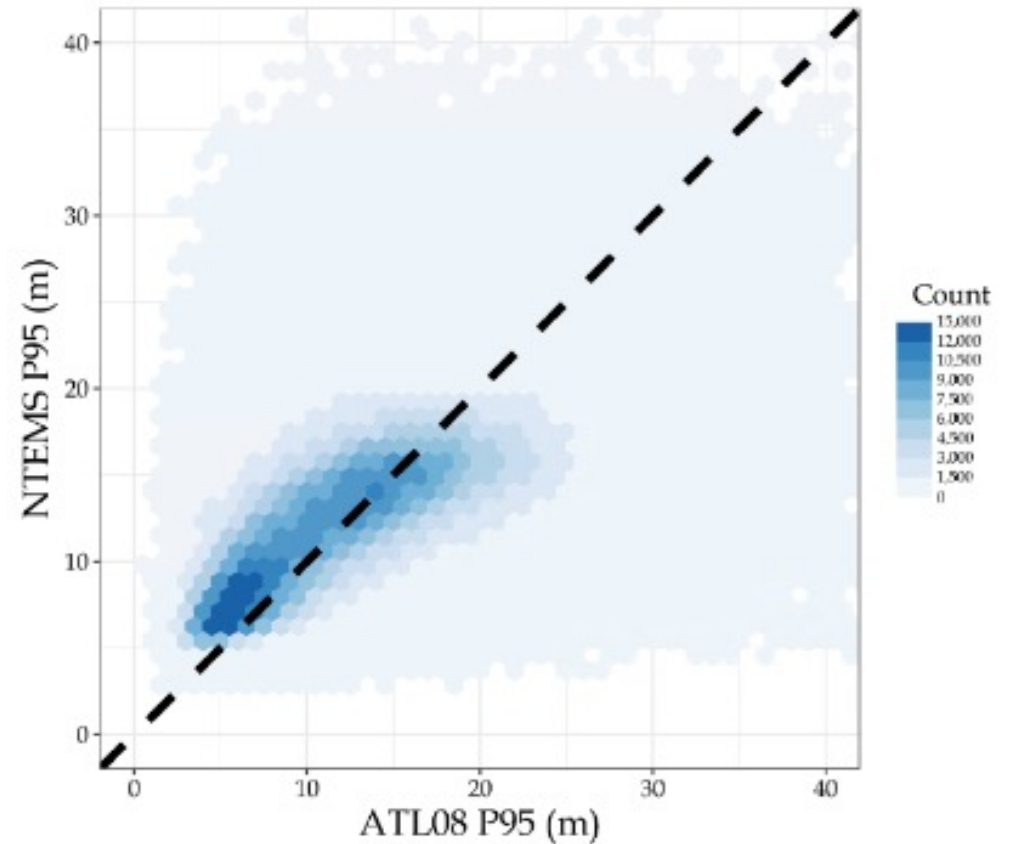
Figure courtesy of Jordon Borak, GSFC

Release 004 ATL08 parameter h_{canopy} , the 98% RH canopy metric (m), mapped to a 15 arc-second (~ 500 -meter) grid, using ICESat-2 photon returns collected from October 14, 2018 to April 21, 2021. This map includes all available h_{canopy} data and has not been filtered or otherwise subjected to quality checks.

Canopy Heights over Boreal Forests



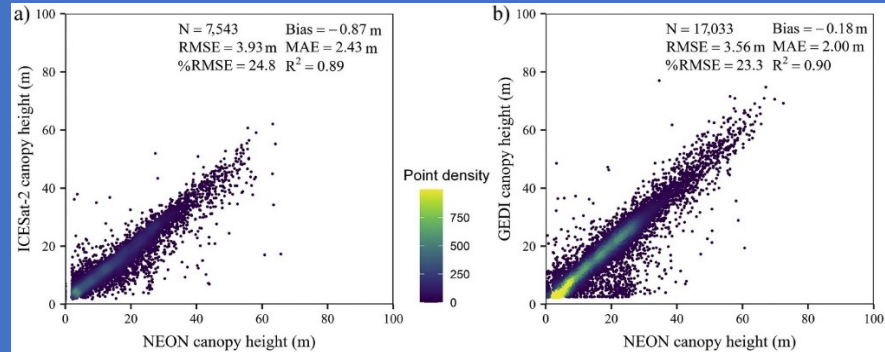
Laura Duncanson, Amy Neuenschwander, Paul Montesano, Nathan Thomas, Alex Mandel, David Minor, Eric Guenther, Steven Hancock, Carlos A Silva, John Armston, Tuo Feng, Ralph Dubayah, Veronika Leitold, Joanne White and Michael Wulder: **Boreal-wide biomass estimation with ICESat-2**



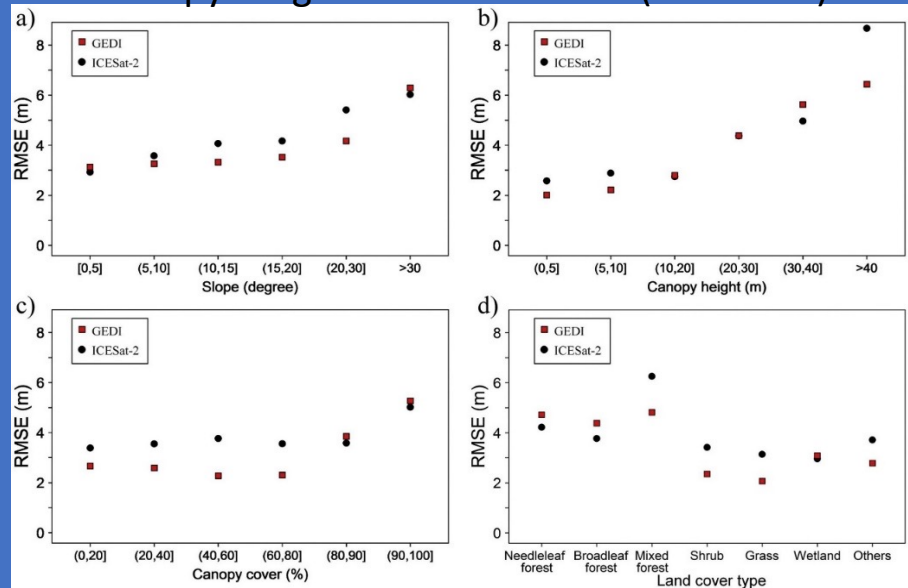
Mike Wulder, Joanne White, Txomin Hermosilla, Nicholas Coops. **Air and spaceborne lidar data as a reference for satellite based forest parameter retrieval and mapping over space and time.**

How Usable are the Data?

ICESat-2 Night: Strong Beams GEDI Night: Power Beam



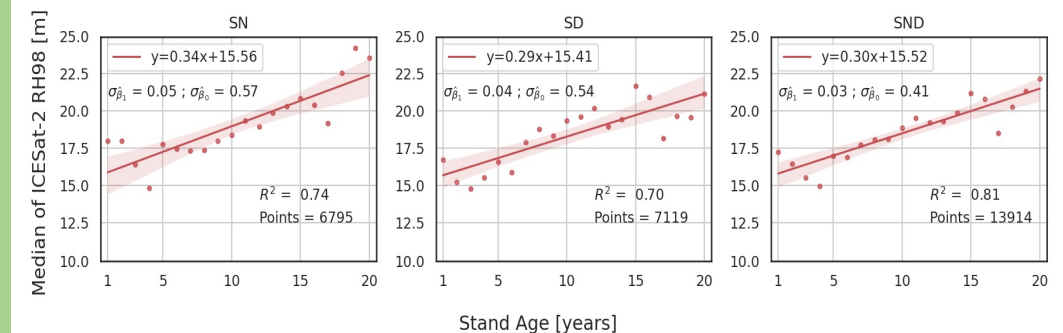
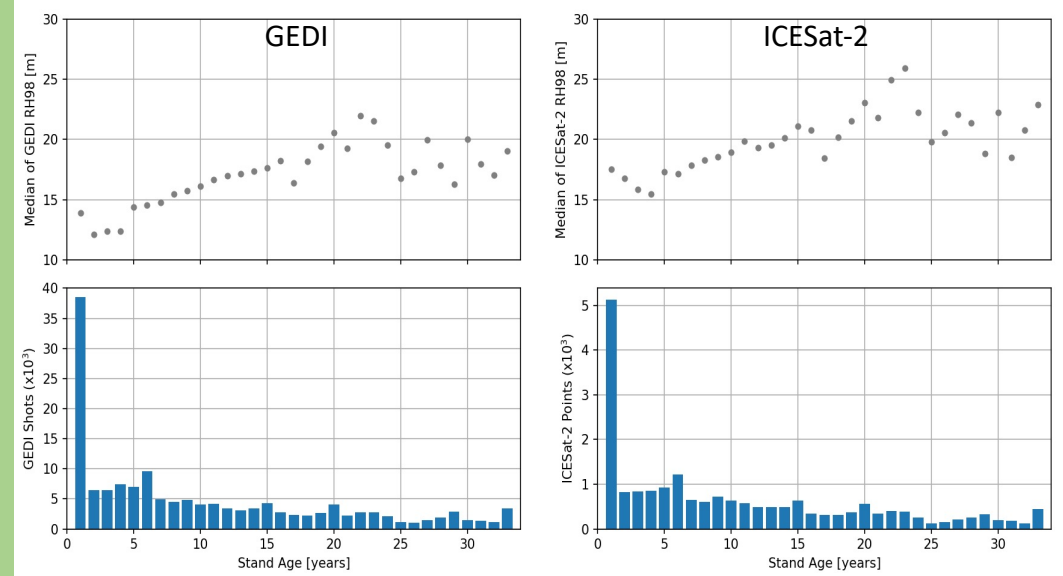
Canopy Height Residuals RMSE (all beams)



Liu, A., Chen, X., and Chen, Z. 2021. Performance evaluation of GEDI and ICESat-2 laser altimeter data for terrain and canopy height retrievals. Remote Sensing of Environment, 264. <https://doi.org/10.1016/j.rse.2021.112571>

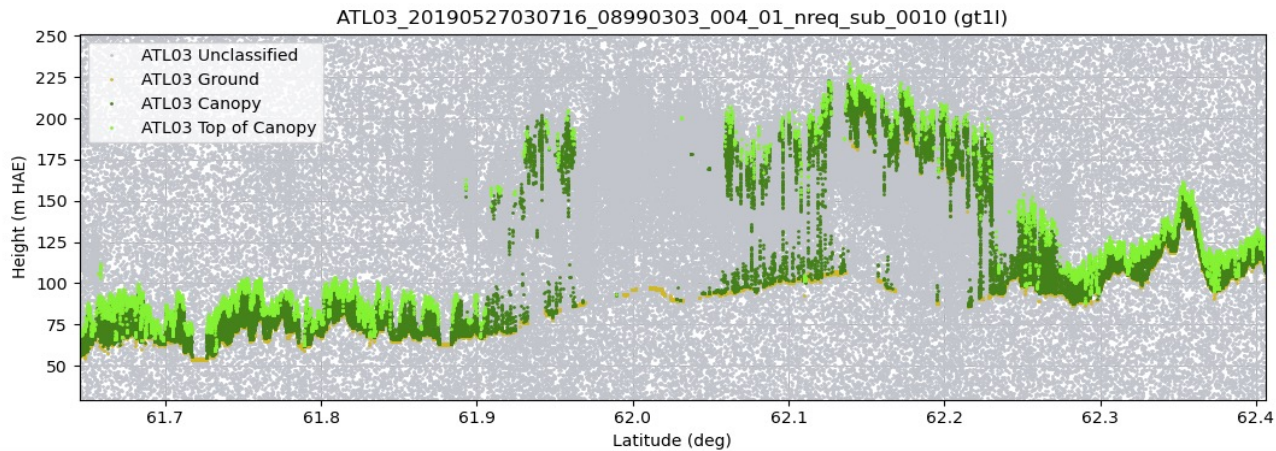
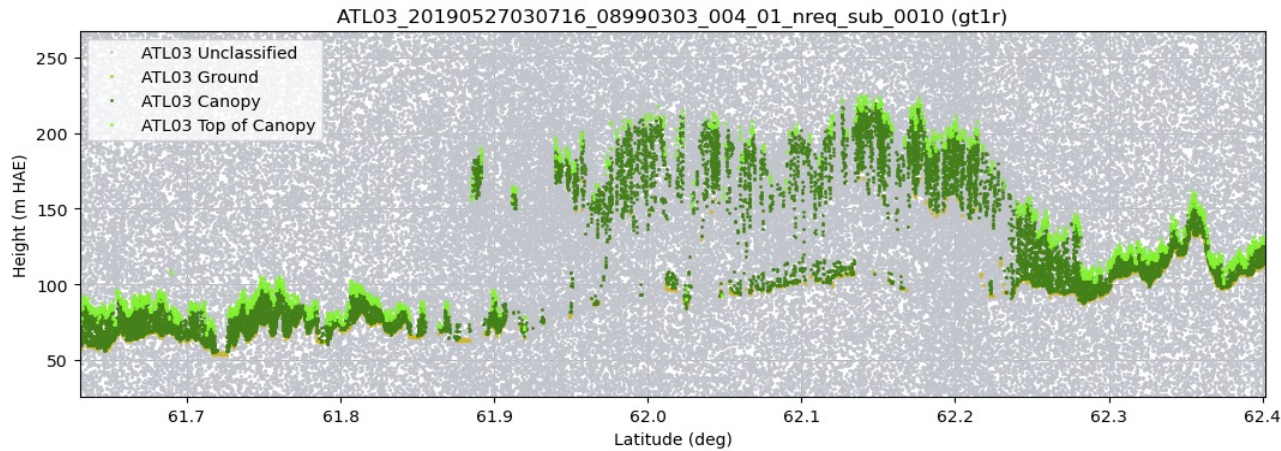
Forestry Regrowth Rate Estimation in Brazil

Figures courtesy of Milutin Milenkovic, Wageningen University



Milenkovic, M., Reiche, J., Armston, J., Neuenschwander, A., Keersmaeacker, W., Herold, M., and Verbesselt, J. (in preparation) Assessing Amazon rainforest regrowth with GEDI and ICESat-2 data

Recommendations on Filtering ATL08



`h_canopy` is the relative canopy height every 100 m

`solar_elev` is the sun elevation angle. Values < 0 indicate night

`msw_flag` is multiple scatter warning flag. The values indicate potential atmospheric scattering that could be affecting the observed heights

`snow_flag` is NOAA daily snow cover flag

`h_dif_ref` is the difference between the ICESat-2 estimated ground height and the reference DEM.

`beam_num`: strong (1,3,5); weak (2,4,6)

Key Takeaways

- ICESat-2 is a space-based, profiling lidar mission
 - Does not provide the same resolution as airborne lidar mapping data
 - Does provide global coverage
- Use of strong beams are recommended for vegetation studies
- Night acquisitions are better than day acquisitions
 - Less background noise
- Data quality should improve over time
 - Improved calibrations of the ranging data
 - Improved modeling of orbital variations
 - Improvements to software will continuously be made
 - data are reprocessed periodically

The background of the slide is a high-resolution image of the ICESAT-2 satellite in orbit. The satellite is a complex, multi-colored structure with a long, thin solar panel extending from its side. It is positioned in the upper left quadrant of the frame, with a green laser beam originating from its base and pointing down towards the Earth's surface. The Earth is visible in the lower half of the image, showing a curved horizon with a mix of white clouds, blue oceans, and brown/green landmasses. The sky is a deep black, filled with numerous small, distant stars.

Tools

<https://github.com/icesat-2UT/PhoREAL>

<https://github.com/ICESAT-2HackWeek>

<https://github.com/Oht0nger/PhoLabeler>

Thank you

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